Practice Question Set For A-Level
Subject : Physics
Paper-1 Topic: Further Mechanics

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Name of the Student:____

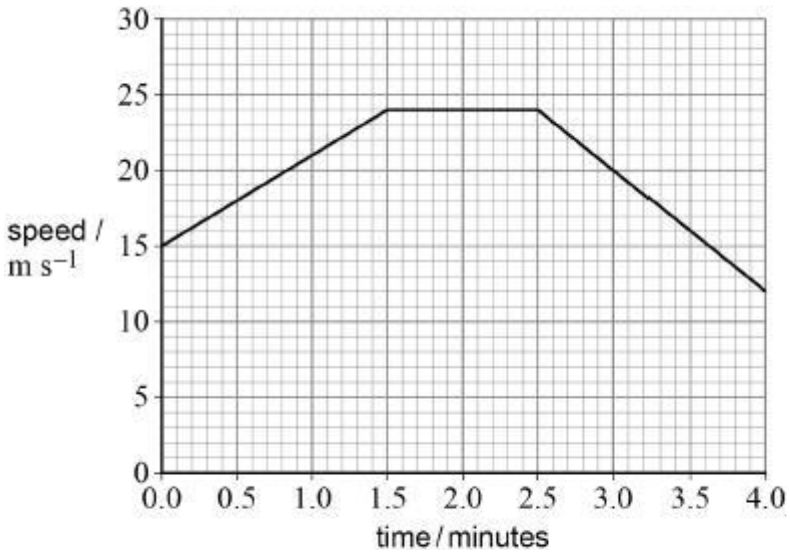
Max. Marks : 25 Marks **Time : 25 Minutes**

Q1.

A pair of cameras is used on a motorway to help determine the average speed of vehicles travelling between the two cameras.

Figure 1 shows the speed–time graph for a car moving between the two cameras.

Figure 1



(a) The speed limit for the motorway between the two cameras is 22 m s^{-1}.

Determine whether the average speed of the car exceeded this speed limit.

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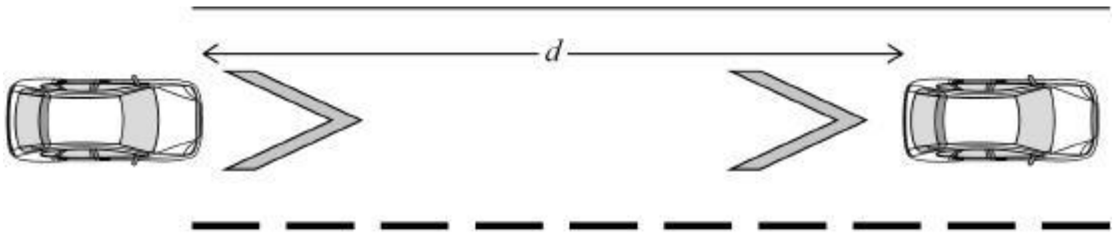
(3)

(b) Markings called chevrons are used on motorways.

The chevron separation is designed to give a driver time to respond to any change in speed of the car in front. The driver is advised to keep a minimum distance d behind the car in front, as shown in **Figure 2**.

Figure 2



not to scale

Government research suggests that the typical time for a driver to respond is between 1.6 s and 2.0 s.

Suggest a value for d where the speed limit is 31 m s^{-1}.

d = _______________ m

(2)

(c) The chevron separation is based on the response time, not on the time taken for a car to stop.

The brakes of a car are applied when its speed is 31 m s^{-1} and the car comes to rest. The total mass of the car is 1200 kg.

The average braking force acting on the car is 6.8 kN.

Calculate the time taken for the braking force to stop the car **and** the distance travelled by the car in this time.

time = _______________ s

distance = ________________ m

(4)

(d) Suggest why the chevron separation on motorways does not take into account the distance travelled as a car comes to rest after the brakes are applied.

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(1)

(e) At bends on motorways the road is sloped so that a car is less likely to slide out of its lane when travelling at a high speed.

Figure 3 shows a car of mass 1200 kg travelling around a curve of radius 200 m. The motorway is sloped at an angle of 5.0°.

Figure 4 shows the weight W and reaction force N acting on the car. The advisory speed for the bend is chosen so that the friction force down the slope is zero.

Figure 3

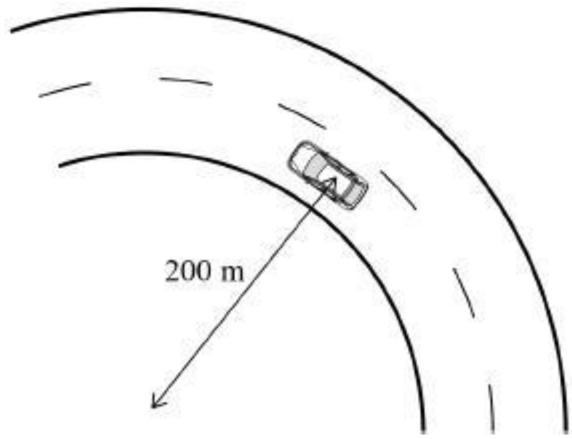
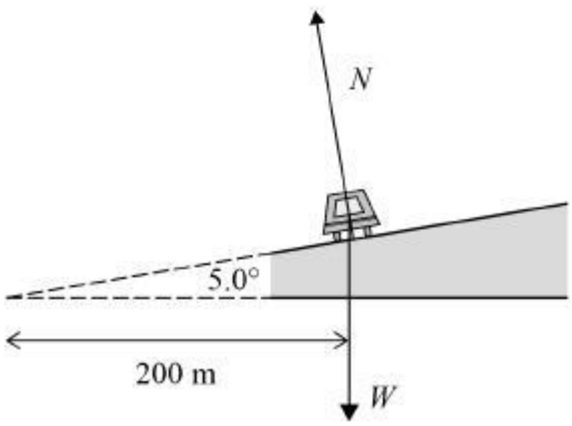


Figure 4



Suggest an appropriate advisory speed for this section of the motorway.

advisory speed = _______________ m s^{-1}

(4)

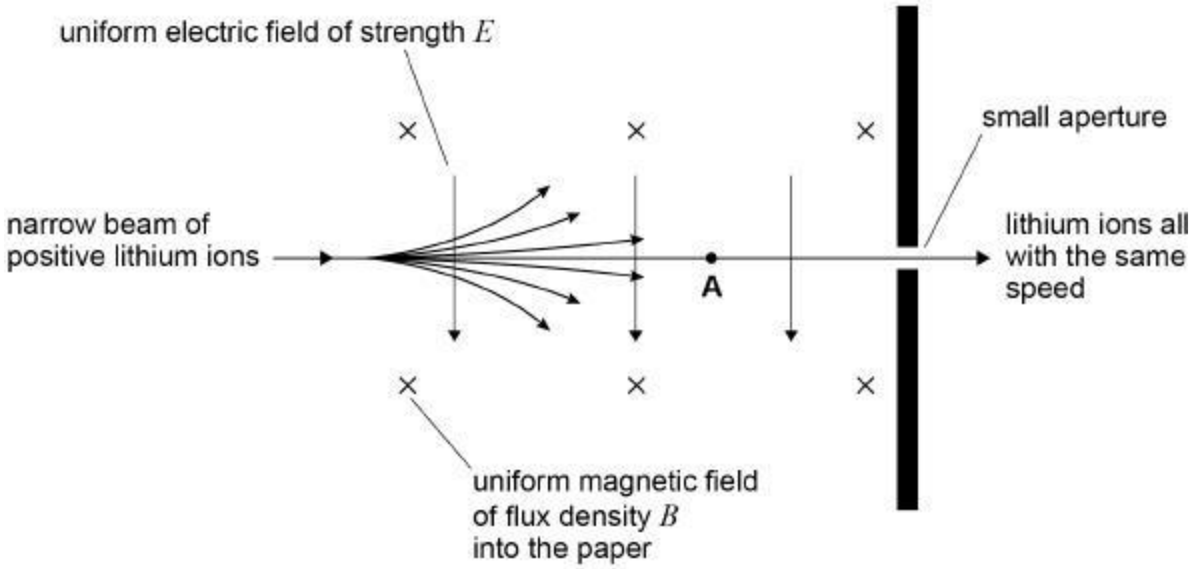
(Total 14 marks)

Q2.

Mass spectrometers are used to measure the masses of ions.

Figure 1 shows one part of a mass spectrometer.

Figure 1



A narrow beam consists of positive lithium ions travelling at different speeds.
The beam enters a region where there is an electric field and a magnetic field.
The directions of the uniform electric field of strength E and the uniform magnetic field of flux density B are shown on **Figure 1**.

Most ions are deflected from their original path.
Lithium ions that travel at one particular speed are not deflected, and pass through the small aperture.

(a) The positive lithium ion **A** in **Figure 1** moves at a speed v.

Draw **two** labelled arrows on **Figure 1** to show the directions of the electric force F_E and the magnetic force F_M acting on **A**.

(1)

(b) Lithium ions travelling at 1.5×10^5 m s^{-1} pass through the small aperture.

Calculate E.

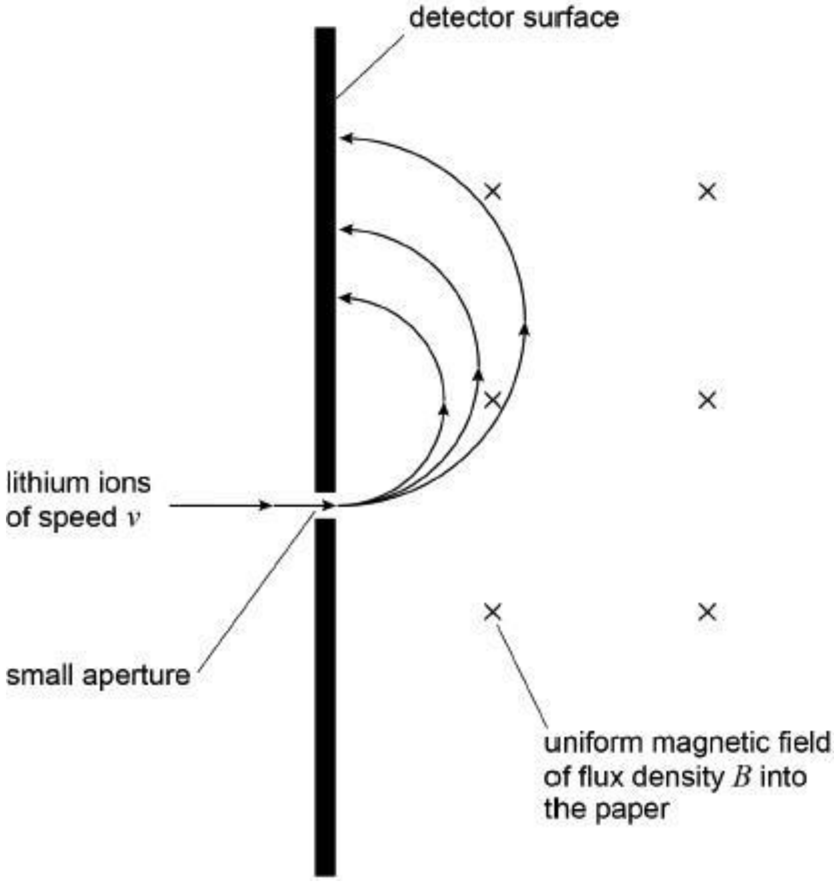
$B = 0.12$ T

E = _______________ V m^{-1}

(2)

(c) Ions that pass through the small aperture enter a second uniform magnetic field of flux density B.
Ions of different mass are separated because they follow different paths as shown in **Figure 2**.

Figure 2



Ions of mass m and charge q travelling at speed v follow a circular path in the uniform magnetic field.

Show that the radius r of the circular path is given by

$$r = \frac{mv}{Bq}$$

(1)

(d) The ions of different mass are deflected and strike the detector surface at different distances from the small aperture as shown in **Figure 2**.

A singly-charged lithium ion $({}^{6}_{3}Li^{+})$ passes through the small aperture.

Calculate the distance between the small aperture and the point where this ion strikes the detector surface.

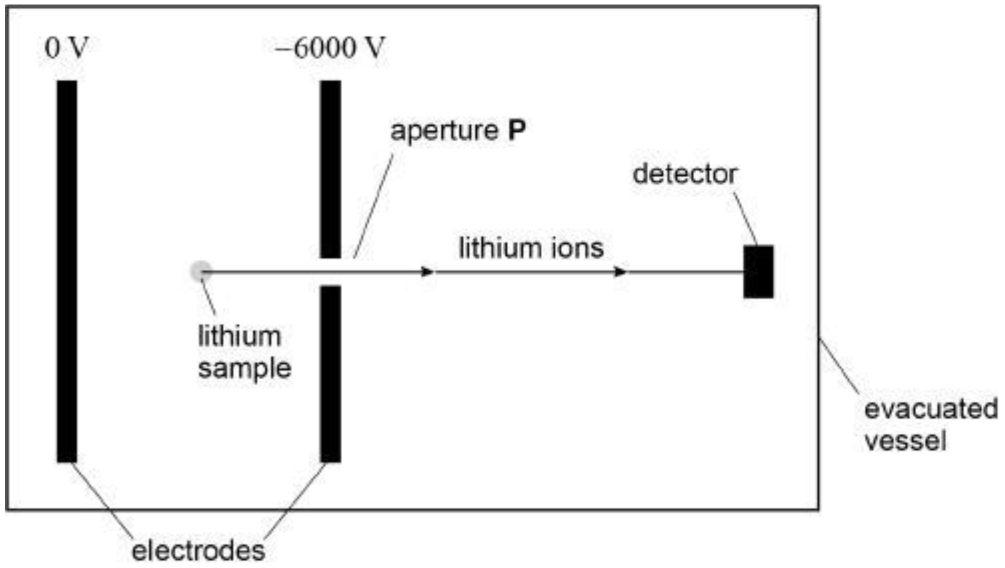
$v = 1.5 \times 10^{5}$ m s^{-1}
$B = 0.12$ T
mass of ${}^{6}_{3}Li^{+}$ ion = 1.0×10^{-26} kg

distance = _______________ m

(2)

(e) **Figure 3** shows a different type of mass spectrometer working with lithium ions.

Figure 3



A stationary $^{7}_{3}\mathrm{Li}^{+}$ ion in the lithium sample is at the mid-point between the parallel electrodes. The $^{7}_{3}\mathrm{Li}^{+}$ ion accelerates towards aperture **P**.

Determine the speed of the ion when it emerges through aperture **P**.

mass of $^{7}_{3}\mathrm{Li}^{+}$ ion = 1.2×10^{-26} kg

speed = _______________ m s^{-1}

(3)

(f) $^{6}_{3}\mathrm{Li}^{+}$ and $^{7}_{3}\mathrm{Li}^{+}$ ions are produced in the sample simultaneously and travel a distance L from aperture **P** to the detector.
For each type of ion, the time interval between production and detection is measured.

Discuss how the masses of the ions can be deduced from the measurement of these time intervals.

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(2)

(Total 11 marks)